INDIANA

DEPARTMENT OF TRANSPORTATION

EXHIBIT "C"

REQUIREMENTS FOR GEOTECHNICAL INVESTIGATION

AND PAVEMENT INVESTIGATION

(FIELD, LABORATORY AND ENGINEERING)

REVISED
JANUARY 1997

EXHIBIT "C"

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11. The memorandum concerning Policy and Procedure for Rock Quality Designation Values on Rock Core Samples obtained for INDOT Purposes dated 3 August 1979;
12. The Color Codes for Utility markings dated 17 December 1980;
13. The memorandum concerning CBR Testing and Data Reporting dated 26 July 1979, and a typical set of Compaction and CBR Test Results;
14. The INDOT "Shale Manual";
15. The check list which the Geotechnical Section uses when reviewing Geotechnical Surveys;
16. Exhibit "E", Requirements for Field Surveys, Adopted 26 June 1967;

EXHIBIT "C"

Requirements for Geotechnical Investigations

A. DESCRIPTION

All geotechnical work performed for the State of Indiana or Local Agencies, such as any Indiana local municipalities and/or county government involving the use of State or Federal funds after 31 December 1996 shall meet the requirements described herein. All the dimensions of the equipments shall meet the requirements of AASHTO and/or ASTM unless otherwise specified in "Exhibit C".

All work performed by the Consultant Geotechnical Engineer under these revised requirements shall consist of making a complete foundation investigation for the adequate design and construction of bridges, roadway or any other associated structures.

A complete foundation investigation shall consist of an adequate program of field sampling, laboratory testing and engineering analysis and evaluation with the results presented in report form. The investigation shall be performed in compliance with the procedures outlined in this document and generally accepted principles of sound engineering practice. The investigation shall be under the general supervision and subject to the approval of the Chief Geotechnical Engineer of the Indiana Department of Transportation. Unless otherwise subsequently noted, later references to as approved or directed will imply as approved or directed by the INDOT Chief Geotechnical Engineer.

B. PERFORMANCE OF FIELD WORK ON PRIVATE PROPERTY

1. Entry Permission

It is the responsibility of the Consultant Geotechnical Engineer to obtain permission for a entry from each property owner whose property must be entered for any reason. Notice of Survey letters must be sent to all affected property owners. Drilling operations cannot proceed until copies of these letters have been received by the Geotechnical Section. The procedure as outlined in Indiana Code 8-13-2-12.2 as amended by Senate Enrolled Act No. 142, First Regular Session 103rd General Assembly must be followed (See Appendix Item No. 7).

2. Damages

It is also the responsibility of the Consultant Geotechnical Engineer acting as a representative of the Indiana Department of Transportation or Local Public Agency to compensate the property owners for any damage incurred to their property because of

the Geotechnical Investigation. Damage compensation should be handled as outlined in the aforementioned Indiana Code.

3. Railroad Expenses

This item consists of the actual cost invoiced by the railroad for such expenses as railroad permits, flagmen, right of entry, etc. The Consultant Geotechnical Engineer shall obtain the written approval of the State before incurring any Railroad Expense.

C. EQUIPMENT

The equipment used shall be hand operated or power drilling, and/or driving equipment, or other tools or equipment considered suitable or necessary for determination of the limits and conditions of the various soil strata, and for obtaining samples for examination, field classification, and laboratory analysis. The equipment used shall be approved prior to site mobilization. A more detailed description of the approved equipment is provided in Section E.

D. LOCATION AND DEPTH OF BORINGS

1. General

This section is to be used as a guide in planning the boring program. It is not the intent that the locations, boring interval and depth specified herein be rigidly adhered to. The Consultant shall make use of available soils and geologic maps, water well records, reports, publications, aerial photographs, and other reference material which are available to prepare a preliminary boring program. Borings shall then be selectively located during a field check attended by the Consultant Geotechnical Engineer. The Geotechnical Consultant should get approval of the boring locations from INDOT before proceeding with drilling operations.

The actual location and spacing of borings shall be dictated by the topography, geologic conditions, visible soil conditions, design considerations, and in accordance with the practices set forth herein. Borings for the general roadway investigation for development of the geotechnical profile generally shall be at the point of maximum grading (cut or fill) along the cross-section unless established on the field check or as otherwise approved.

2. Location of Roadway Borings

In general, roadway borings should be spaced 150 to 250 meter intervals except as noted below for Items D.2.c, D.2.d., and D.2.e. Intervals up to 300 meters are acceptable for reconstruction projects where only minimal grading is proposed and is outlined in Guidelines for Conducting Subgrade Investigation. The following should be considered when determining roadway boring locations and intervals:

a. Points of Maximum Cuts

b. Points of Maximum Fill

c. Proposed Drainage Structures

1) Storm Sewers: Locate boring over proposed sewer at points of maximum invert depths.

2) Small Culverts [Less than 1.2 meter]: A minimum of one sounding should be made at each end of the pipe within the existing ditch, creek or stream channel to determine the depth of any soft soils to be removed. The depth of soundings shall extend a minimum of one pipe diameter below the proposed flow line, or into firm material.

3) Large Culverts [1.2 meter or larger]: For all drainage structures 1.2 meter or wider, the minimum number of borings and soundings required depends on the pipe length as summarized below.

I. Drainage structures under divided highway with median, a minimum of one (1) boring shall be made near each outside shoulder at the proposed maximum fill height. **The depth of the borings should be a minimum of twice the drainage structure width below the invert elevation or 2/3 of fill height or into firm material whichever is deeper.** For multiple drainage structures, borings shall be staggered to cover each drainage structure.

II. Drainage structures less than fifty (50) meters long will require a minimum of one (1) boring near the maximum proposed fill height. **The depth of the borings should be a minimum of twice the structure width below the invert elevation or 2/3 of the fill height or into firm material, whichever is deeper.**

III. Drainage structures greater than or equal to fifty (50) meters long will require one (1) boring near each outside shoulder at the proposed maximum fill height. The depth of the borings shall be in accordance with part 3.II. above.

IV. Drainage Structure crosses an existing ditch, creek, or stream channel, the boring criteria above should be followed in addition to locating the required boring in the existing channel. If the boring criteria above cannot be met by locating the

boring in the existing channel, then a minimum of one (1) additional boring may be required where the drainage structure crosses the channel to provide the necessary subsurface information. Soundings should be performed between borings and at the ends of the drainage structure. The depth of borings shall be in accordance with part I (above). The depth of soundings shall extend a minimum of one pipe diameter below the proposed flow line, or into firm material, whichever is deeper. If the borings in the existing channel are inaccessible to truck, then a skid rig or tripod equipment should be used to obtain the samples.

d. Structure on Footings (Plate Arches & Box Culverts)

Often times large structures are proposed which are not considered to be bridges by the INDOT Division of Design. Examples of these structures are structural plate arches on footings (bottomless) and box culverts on footings (bottomless). In general, borings should be placed under the footings along the entire length of the structures, including wingwalls, at intervals of approximately 30 meters and at the ends. Where the proposed footing crosses an existing stream bed, soundings should be performed between the borings and at the ends within the existing stream bed. The depth of borings and soundings shall be in accordance with the guidelines described in part 3. I. and II.

If the existing channel is relocated and part of the footing lies within the existing channel, borings should be located under the footing within the existing channel along the entire length of the structures, at intervals not exceeding thirty (30) meters and at the ends. The borings should alternate from one side to the other. Soundings should be performed between the borings and at the ends within the existing and the proposed channel.

If the borings in the existing channel are inaccessible by truck, then a skid rig or tripod equipment should be used to obtain the samples.

e. Retaining Structures

Borings for proposed retaining structures should be located along the proposed alignment of the retaining structure and spaced approximately thirty (30) meters apart, but not to exceed ninety (90) meter intervals depending on the type, height, and length of the structure. Retaining structures which are less than thirty (30) meters long should have a minimum of two (2) borings out of which one (1) boring should be located at the point of maximum height. The depth of boring shall be a minimum of two (2) times the width of the footing (if

known) or 1.5 times the total height of the wall (if footing width is not known), or into firm material, whichever is deeper.

f. Weak Subsoils

If weak soils are encountered, undisturbed sampling may be required for strength and consolidation testing and analysis. Additional borings and soundings may also be required to define the limits of weak subsoils, all with prior approval.

Soundings are made to determine the depth and limits of unsuitable materials, giving a general description of material and approximate depth of strata change. Soundings should also be made in ditches and ponds to be covered by embankments and at each proposed culvert & retaining structure location (where borings were not performed) to determine the anticipated depth of soft sediment removal.

g. Wide Median

If the proposed construction is to consist of more than one pavement, separated by a median of sixty (60) meters or more, then each pavement shall be considered as a separate roadway and borings should be located accordingly.

h. Peat, Muck and Marl Deposits

In areas where peat, muck and marl deposits are known or suspected to exist, the roadway borings shall be carefully located and the interval substantially decreased to insure that all deposits may be located. In addition to roadway borings in these areas, check soundings shall be made to verify the depth and limits of unsuitable material.

For dual lane pavement, soundings are generally made at survey centerline and offsets at the half distance to construction limits and at the construction limits at each station to define the limits of the deposit; for single pavement, soundings shall generally be at centerline and construction limits at each station, all with prior approval. If marl or marly materials are encountered, arrangements should be made with the Chief Geotechnical Engineer so that representative point five (.5) kilogram sample can be tested for their calcium and magnesium carbonate content at the INDOT - Geotechnical Section's laboratory. The test results will be provided to the Consultant Geotechnical Engineer to be incorporated into the Special Laboratory Test Results section of the report.

i. Rock Cuts

If rock cuts are anticipated or the roadway borings encounter rock in cuts, a minimum of two rock core borings may be required at a selected representative cross-section, preferably at the deepest point of cut, in order to determine the quality, quantity, stratification and dip of the rock. These rock core borings shall be made in each ditch line. In deep cuts, additional rock core borings may be required near the top of rock backslope, or as required and previously approved.

In addition to rock core borings in rock cuts, soundings may be required. The soundings shall be located to develop accurate "top-of-rock" cross-sections of the rock cut at thirty (30) meter intervals or as directed.

j. Man-Made Waste Fills

1) Areas Known Prior to Geotechnical Investigation

When man-made solid waste or hazardous waste fills are known to exist in the proposed corridor by direct reference in the Highway Location Study Report, the Consultant Geotechnical Engineer will be responsible for conducting the work in compliance with all applicable local, state and federal laws and regulations.

a) Non-controlled or Non-hazardous Waste Material

If the waste fill consists of trash, rubbish, debris or other non-hazardous or non-controlled solid waste, the fill shall be investigated by borings and/or soundings to determine the limits of unsuitable material. The limits should include both the depth and the lateral extent within the proposed roadway corridor.

b) Controlled or Hazardous Waste Material

If the waste fill consists of any hazardous or controlled substances, as determined by the INDOT Environmental Assessment Section, the Geotechnical Investigation will not be performed in the areas in question.

2) Areas not Known Prior to Geotechnical Investigation

When man-made waste fills are unexpectedly encountered during the Geotechnical Investigation, the Consultant Geotechnical Engineer shall

cease drilling in the questionable area immediately and notify the INDOT Chief Geotechnical Engineer of the discovery. The INDOT Environmental Assessment Section will be contacted by the INDOT Geotechnical Section and consulted to the probable contents of the waste fill. Work can only continue in the questionable area with the consent of the INDOT Environmental Assessment Section following the applicable procedure previously outlined in Part 2.j.1.

k) Channel Cuts

Sufficient borings shall be made in proposed channel cuts to determine the suitability of the material for use in embankments, the stability of proposed slopes, the need for erosion control, and other geotechnical considerations related to the proposed channel change. Borings shall also be made in abandoned meanders and stream crossings traversed by the line to determine whether unsuitable material will be encountered. Soundings will be required to delineate the limits of unsuitable material and to determine if stability or settlement analysis will be required.

l) Landslide Areas

If the Consultant Geotechnical Engineer is in an area where a landslide has occurred, he should notify the Chief Geotechnical Engineer to discuss the proposed type, location, and depth of borings.

3. Depth of Roadway Borings

a) Cut Sections

Generally borings in cut sections shall penetrate to a depth of two point one (2.1) meter below the proposed grade line. Borings shall not stop in soft, very loose or questionable soils but should be extended one (1) meter minimum into firm material, unless otherwise approved. If the top of rock is encountered below subgrade elevation, the core borings on the centerline shall extend at least one point five (1.5) meters into the rock. Cut section borings made in the ditch line shall extend point six (.6) meters below flow line or two point one (2.1) meters below grade line, whichever is deeper. Core borings made in the rock backslopes shall be to a depth as approved previously.

Soundings made to determine the limits of rock shall be discontinued at the rock surface one point two (1.2) meters below proposed grade line, whichever depth is encountered first, or as otherwise approved.

b. Fill Sections

Generally roadway borings in fill sections shall penetrate to a depth of one point eight (1.8) meters or 2/3 of the height of proposed embankment, whichever is greater, or as previously approved. Where fills cross stream flood plains, old lake beds, ponds, or other areas of suspected compressible or low-strength foundation soils, the borings shall penetrate to a minimum depth equal to the fill height, or as previously approved. Borings shall not be terminated in soft, very loose or questionable soils but should be extended to a suitable depth into firm material.

If rock is encountered in fill sections, the borings shall be discontinued at auger refusal or the proposed depth as determined above (whichever is shallower). One core boring shall be made one point five (1.5) meters into the rock to establish its quality.

c. Peat, Muck and Marl Deposits

In areas where peat, muck and marl are encountered, roadway borings shall penetrate layers of peat, muck and marl and extend a minimum of one point eight (1.8) meters into firm underlying soil or to the depth specified for Fill Section, whichever is greater. Soundings shall penetrate all layers of peat, muck and marl and extend a minimum of six (6) meters into firm underlying soil.

If marl or marly materials are encountered in the borings, representative point five (0.5) kg samples should be delivered to the INDOT-Geotechnical Section for testing purposes as mentioned in D.2.h. (LOI. Ca & Mg.)

d. Man-Made Waste Fills

Borings and soundings shall penetrate any trash, rubbish, debris, commercial waste, or other like materials and extend into firm material. All work in man-made waste fills shall be done in accordance with section D.2.j.

e. Channel Cuts

Borings in channel shall extend a minimum of point six (0.6) meters below the proposed flow line of the channel.

4. Soil Subgrade Investigation

A soil subgrade investigation will be performed on all projects where the existing pavement will be removed and replaced. The following procedure should be used when conducting a field investigation of existing roadway subgrade soil conditions.

a. Location of Boring

Soils subgrade borings are generally located in areas of "at grade" sections or minimal cut and fill of up to point six (0.6) meters. Borings should be placed approximately at three hundred (300) meter intervals on all pavement reconstruction projects (pavement removal and replacement). In addition to this, borings should be alternated from right and left lanes. In the case of divided highways the borings should be located in the driving lanes, alternating from right to left side.

b. Depth of Boring

Soil Subgrade borings shall extend to a minimum depth of one point two (1.2) meters below the proposed subgrade material or two (2) split spoon samples (into medium stiff/medium dense, sub-soil), whichever occurs first.

c. Boring and Sampling

1) Coring of Existing Pavement

If pavement cores are needed for Analysis or testing, then the existing pavement shall be cored with a two hundred (200) or two hundred and fifty (250) millimeter core barrel. The core is to be retrieved and properly labeled (boring number, project, road) and brought in to lab for further analysis (if required). Boring logs are to reflect core thickness and overlay type and thickness (if present).

If pavement core samples are not required, then other methods of drilling through the pavement may be used, if desired. Payment will be made only for those cases where reinforced concrete pavement is encountered and coring is therefore a necessity.

2) Augering Thru the Subbase Material

Once the pavement has been removed and logged, the boring shall be extended by augering with hollow stem augers to the bottom of the subbase material and logged accordingly. The subbase material shall be removed from the hole by hollow stem auger and cleaned out by hand.

3) Subgrade Sampling

When the top of the subgrade soil is reached and four hundred and fifty (450) millimeter split spoon sample shall be taken and logged.

A split spoon sample shall be obtained with the standard spoon of fifty-one (51) millimeter O.D. and thirty-five (35) millimeter I.D., driven with a 63.5 kilogram hammer, dropped seven hundred and sixty (760) millimeter. The number of blows of the drop hammer to drive the spoon four hundred and fifty (450) millimeters, measured in one hundred and fifty (150) millimeters increments, shall be recorded. The penetration resistance, or N-value, shall be as defined in ASTM Standards, and is normally the number of blows to drive the sampler the last three hundred (300) millimeters, (the sum of the second (2nd) and third (3rd) one hundred and fifty (150) mm increments).

Two (2) jar samples approximately one hundred and twenty-five (125) millimeters long shall be obtained from each spoon for laboratory examination and/or testing. Care shall be taken to keep the jar samples as intact as possible. The samples shall be immediately placed in sealed glass containers to prevent loss of moisture.

If the N value is 10 blows or less, and the soil is cohesive, a point six (0.6) meters long and fifty-one (51) millimeter diameter shelby tube sample shall be taken beside the split spoon sample within the same pavement core hole. If the N value is eleven (11) or greater, no shelby tube sample shall be required and the boring shall be extended to the bottom of the first split spoon depth and the procedure repeated.

If a shelby tube sample is required, it shall have a minimum recovery of fifty (50)%. If this is not obtained from the first tube, a second tube will be required as previously described depending on the soil encountered, so that a combined total of not less than a four hundred and fifty seven (457) millimeter undisturbed sample is obtained.

Once the first set of samples have been completed (as described above) the boring shall be extended to the bottom of the first sample depth and the procedure described above shall be repeated a second time.

If the N value on the second split spoon is six (6) or greater the boring is to be terminated at this point. If the N value is less than six (6), and if the soil is cohesive a second shelby tube sample is required at the

corresponding depth plus one hundred and fifty (150) millimeter. Again, a fifty (50)% minimum recovery is required.

When the second shelby tube is required due to N values being less than six (6), a third split-spoon sample is required immediately below the second shelby tube sample depth. Once this sample is recovered and logged the boring shall be terminated, regardless of the blow counts.

4) Bag and CBR Samples for Soil Subgrade Investigation

It shall be noted that every soil type (cohesive) that is encountered on a given project shall have an eleven (11.0) kilogram disturbed bag sample, and this bag sample shall be taken from the subgrade soils.

A CBR sample one-hundred and thirteen (113) kilogram minimum is required for each project. This sample is to be taken under paved shoulder from the most predominant cohesive soil type that is encountered on the project site. For further CBR sample collection information, see guideline dated 18 December 1990 in the Appendix of this document.

5) Groundwater Readings and Backfilling Holes

After the above noted procedure has been completed, a completion water depth must be recorded on the boring log. The bore holes shall then be suitably covered so that there will be no hazard to people, animals, or equipment. After 24 hours a second water reading shall be taken and recorded on the log. At this time the boring shall be backfilled with either "cold patch" asphalt, "quick set" concrete or other suitable material, as approved by the appropriate maintenance district or the Division of Materials & Tests.

5. Location of Structure Borings

Structure borings shall generally be located on a preliminary basis by the Geotechnical Consultant Engineer with final approval being given by the Chief Geotechnical Engineer. See "General Instructions for Bridge Structure Investigations" in the Appendix.

6. Depth of Structure Borings

The depth of structure borings shall be determined as set out in the most recent "General Instruction for Bridge Structure Investigations", making sure that the scour condition is observed, if applicable, or as directed.

E. BORING AND SAMPLING

1. General

a. Standard Penetration Tests

Generally, all borings should be performed with split-spoon sampling. Samples should be taken at the 0.75 meter intervals for the upper three (3) meter and 1.5 meter intervals thereafter.

b. Split-Spoon Sampling

Split-spoon samples shall be obtained with the standard fifty-one (51) millimeter O.D. and thirty-five (35) millimeter I.D. driven with a 63.5 kilogram hammer, dropped seventy-six (760) millimeters. The number of blows of the drop hammer to drive the spoon four hundred and fifty (450) millimeters, measured in one-hundred and fifty (150) millimeter increments, shall be recorded. The penetration resistance, or N-value, shall be defined in ASTM Standards, and is normally the number of blows to drive the sampler the last three hundred (300) millimeters of a four hundred and fifty (450) drive (sum of second (2nd) and third (3rd) one hundred and fifty (150) mm increments).

Two (2) jar samples approximately one hundred and twenty five (125) millimeters long shall be obtained from each spoon for laboratory examination and/or testing. Care shall be taken to keep the jar samples as intact as possible. The samples shall be immediately placed in sealed, clean, glass containers to prevent loss of moisture. Moisture content determinations will be performed in accordance with the guidelines set forth in Section G.3.c.

c. Sample Handling

All of the samples should be delivered to the Consultant Geotechnical Engineer's laboratory for representative classification tests, CBR tests, and other tests as required.

All samples shall be retained by the Consultant Geotechnical Engineer for at least ninety (90) days after final acceptance of the Geotechnical Report during which time the State may request that all or part of the samples be delivered to the Geotechnical Section of the Indiana Department of Transportation.

d. Sample Identification

All laboratory samples shall be suitably marked and identified to show sample number, project number, road number, county, structure number, depth below ground surface, boring number, and blow count for each one hundred and fifty (150) millimeter interval (if applicable). Undisturbed samples should, in addition, have a description of the soil. (Also see Sections E.3 and F.)

The INDOT Division of Materials and Tests Central Test Laboratory will not accept any soil and/or rock samples known to be contaminated with any Federally regulated hazardous chemical or waste without prior notice, written approval and accompanied by the proper MSDS detailing the material and all potential hazards associated with the material.

Any samples which are received at the INDOT Central Test Laboratory which are not properly labeled or which are not accompanied by a required MSDS, will be returned to the sender without any further action or testing being performed. A laboratory number will not be assigned to such improperly labelled samples. All soil samples must be labeled as "soil" on the jars.

e. Ground Water Readings and Backfilling

Note and record depth to ground water encountered during drilling. When water is added during drilling to keep the hole open, the depth should also be noted on the boring log. After measuring the ground water level at completion of the borings, the bore holes shall be suitably covered so that there will be no hazard to people, animals or equipment. It may be necessary to use a pvc casing in order to keep the hole open to record twenty-four (24) hour readings. After the twenty four hour (24) ground water level has been measured as well as the depth to which the hole remained open, (or cave-in to) and all other observations, records and information have been obtained, the holes shall be backfilled in strict compliance with the current Indiana Department of Transportation "Aquifer Protection Guidelines" dated 9 December 1985 and revised 30 October 1996. Borings drilled through

existing pavement should be suitable patched. The Consultant Geotechnical Engineers attention is directed to the "Method for Drilling Through and Repairing Bridge Decks". The methods outlined in that document should be adhered to in all applicable situations, except as otherwise approved.

f. Special Backfilling of Boreholes

This work shall be accomplished in strict compliance with the current Indiana Department of Transportation "Aquifer Protection Guidelines" dated 9 December 1985 and revised 30 October 1996, except when the borehole caves in. In this case the borehole shall be backfilled from the top of the cave-in to the ground surface using the "Aquifer Protection Guidelines". Please note that except for instrumentation, these guidelines pertain to natural ground, and so the depth of fill material is first subtracted before the depths below apply.

1) Boreholes Between 3 to 9.0 Meters Deep in Natural Ground

Boreholes between three (3) to nine (9) meters deep; backfilled in accordance with Section II.B of the Guidelines. This item includes all equipment, material and labor to complete the task.

2) Boreholes Greater Than 9 Meters Deep

Boreholes greater than nine (9) meters; backfilled in accordance with Section II.C. of the guidelines. This item includes all equipment, material and labor to complete the task.

2. Boring Methods

a. Mobilization of Drilling and Coring Equipment

This work shall consist of mobilization of equipment to and from the drilling site and shall be paid for from Indianapolis or to the next drilling site under this Agreement on the basis of the mileage shown of the current Official Highway Map to the nearest town. This item shall consist of a lump sum fee plus a mileage charge. If more than one site is to be drilled, INDOT may schedule the order in which the sites are to be drilled to minimize the total road mileage. Mobilization of barge drilling equipment is excluded from this item as it is a separate pay item.

If a combination of truck mounted and skid/ATV mounted borings exist on any project and each type of equipment is actually mobilized, then two (2) mobilization fees shall be paid. If the additional cost of doing the truck borings with the skid rig is less than the additional cost of the second mobilization, then all borings will be paid as skid borings and only one rig will be mobilized. The most cost-effective method shall be used. However, if more than one rig type will be needed a prior approval is required from the Chief Geotechnical Engineer.

b. Remobilization

Remobilization shall be paid only after having received authorization prior to equipment removal from the project site, or if an unforeseen change in the scope of work is made after the initial demobilization. Payments for the remobilization will be made per remobilization, which are previously authorized in writing.

c. Hand Borings

This work shall consist of using a hand auger of minimum thirty-eight (38) millimeter diameter, twenty-five (25) millimeter retraction piston sampler, peat sampler, seventy-six (76) millimeter minimum diameter postole type auger, or a hand guide power auger for obtaining samples for determining the geotechnical profile. This work shall be performed in accordance with AASHTO T-203. The increment of advance of hand augers shall not exceed one hundred and fifty (150) millimeters. Payments shall be made from the ground surface to the maximum depth of auger penetration.

d. Truck Drilling

1) Truck Mounted Borings With .6 Meter Auger Head

This work shall consist of using a truck mounted drilling rig to obtain disturbed samples for use in determining the geotechnical profile. This drilling method shall be used only in materials that do not cave into the holes upon retraction of the auger. This work shall be performed in accordance with AASHTO T-203, except the Consultant Geotechnical

Engineer shall use an auger head point six (0.6) meters maximum length retracted after every .6 meters of penetration. There shall be no auger flights for the first 0.9 meters above the top of the 0.6 meters auger head. The soils removed with

the auger shall be carefully examined, manipulated, visually classified, and a sample shall be taken; the auger shall be cleaned, advanced in the boring, and the sequence repeated until the required depth of boring is reached. Payment will be made from the ground surface to the maximum depth of auger penetration.

2) Truck Mounted Borings with Split-Spoon Sampling

This work shall consist of using a truck mounted drill rig to advance a hole of sufficient diameter for the purpose of taking fifty-one (51) millimeter O.D. split spoon samples and making standard penetration tests at 0.75 meter intervals for the first three (3) meters and at the 1.5 meter intervals thereafter including a sample at the bottom of the boring with the possibility of taking seventy-six (76) millimeter O.D. Shelby Tubes and fifty-four (54) millimeter diameter rock cores. This work shall be performed in accordance with AASHTO T-206, and as stated in Sections E.1.a and E.1.b. Payment will be made from the ground surface to the maximum depth of penetration of the last split-spoon.

When a free-falling hammer is used, a maximum of two (2) wraps of rope around the cathead shall be used to minimize reduction of the energy due to frictional resistance of the falling hammer. Other precautions shall be exercised to insure a free-falling hammer.

Drilling fluid or other authorized practices shall be used in circumstances where sand heaves into the casing or as previously approved. Any unusual sampling procedures or results shall be noted on the boring log.

Driving of the split-spoon will be discontinued when blow counts reach one-hundred (100) for a penetration of three hundred millimeters or less.

If a sample is not recovered less than (40% recovery) upon retraction of the sampler one (1) attempt with an appropriate entrapment device shall be made in order to retrieve a sample for visual classification.

3) Truck Mounted Rock Core Borings

This work shall consist of using a truck mounted drill rig for rock core drilling. Standard diamond core bits and series "NWG" or "NX" or larger double-tube or triple-tube core barrels to obtain fifty-four (54) millimeter diameter core shall be required for making rock core borings. The maximum length of core barrels, and the maximum length of each core run, shall be 1.5 meters, unless otherwise approved. All rock cores recovered shall be retained and protected.

If shale or any other non-durable sedimentary rocks are encountered, the core samples should be sent to the Division of Materials & Tests for laboratory testing. The test results will be made available to the Consultant Geotechnical Engineer to incorporate into the Report and for use in making engineering decisions.

Rock cores shall be placed securely in suitable compartmented wooden or plastic boxes with lids, in the order in which removed from the boring, with dividers between core runs, with the top and bottom depths of each run suitably labeled. Suitable labeling shall also be done on the outside end of the core box. Payment will be made for the actual number of lineal meters cored.

4) Truck Mounted Drilling Through Bedrock or Boulders or Concrete Pavement

This work shall consist of advancing a hole using truck mounted equipment through boulders, bedrock or concrete pavement (for Subgrade Investigation) using a Hawthorne Rotary Drag Bit, Tri-Cone Roller Bit, or other suitable equipment, and using whatever method and equipment necessary to keep the hole open for the purpose of taking Standard Penetration Tests, split-spoon samples, obtaining undisturbed samples, rock core samples, etc. For the purpose of clarification for this item only, bedrock shall be considered as material which meets the criteria for split-spoon driving discontinuation as explained in (E.2.d.2).

e. Skid Drilling

The following items (1. Through 4.) are to be used when site conditions are such that a skid-mounted, dozer mounted, all terrain vehicle drill rig or any other type mount previously approved is required to obtain the borings. Borings where the Consultant Geotechnical Engineer is required to use a dozer to get a rig to the boring location shall also be considered under this item. If the Consultant Geotechnical Engineer chooses to use a skid-mounted, dozer-mounted, or all-terrain vehicle rig to obtain borings which could have been obtained by a truck rig, they shall be considered as truck borings.

1) Skid Mounted Borings with .6 Meter Auger Head

This work shall be the same as described in (E.2.d.1), except for the drilling equipment required.

2) Skid Mounted Borings with Split-Spoon Sampling

This work shall be the same as described in (E.2.d.2), except for the drilling equipment required.

3) Skid Mounted Rock Core Borings

This work shall be the same as described in (E.2.d.3), except for the drilling equipment required.

4) Skid Mounted Borings Through Bedrock or Boulders or Concrete Pavement

This work shall be the same as described in (E.2.d.4), except for the drilling equipment required.

f. Barge Drilling

The following items (1 and 2) are to be used when flotation equipment is required to make borings over water. Flotation equipment is described as a barge, raft, boat, or platform of sufficient size to properly and safely support the drilling equipment and have sufficient area for working and storage of the necessary tools and supplies required to make water borings. The barge and drilling equipment shall be of sufficient size to operate on any body of water within, or bordering the State of Indiana and be able to penetrate to depths as

required. The equipment shall also be capable of obtaining seventy-six (76) millimeter O.D. Shelby Tubes at depths requested by the Consultant Geotechnical Engineer with prior approval. Water borings shall be generally defined as those where water is to a depth where it is not feasible to drill with equipment resting on the stream bed or earth ramp, all subject to prior approval. It shall be the Consultant Geotechnical Engineer's responsibility to determine the elevation and depth of the water at the time the drilling is performed.

1) Floating Equipment for Hand Borings

This work shall consist of furnishing a boat or other suitable floating equipment for the purpose of making hand borings or soundings in streams, ponds, or lakes. A quantity of one lump sum will be paid for the project, if required.

2) Floating Equipment for Machine Borings

This item shall consist of mobilization, demobilization, tearing down, equipment rental and setting up of equipment required for barge machine boring at a drilling site. Only one barge set-up will be allowed per drilling site, unless two different barges are required (i.e., one type for navigable water and one type for non-navigational water) in which case two barge set-ups will be allowed. A drilling site is defined for this item as one or more barge borings located less than eight (8) kilometers from any other barge boring. The drilling site shall be considered as being on navigable water or non-navigable water as defined by the jurisdiction of the United States Coast Guard.

a) Navigable Water

(i) Barge Set-Up (Floating Equipment for Machine Borings)

(ii) Rental of Support Equipment

This item shall consist of the rental of support equipment required to perform barge borings on navigable water. Support equipment such as the barge rental, tug boats, cranes, additional special equipment, etc., shall be reimbursed at the actual invoice cost plus 10%. The ENGINEER shall obtain the written approval

of INDOT before incurring any Support Equipment expenses.

(iii) Drill Rig Down Time (Water Set-Up)

This item shall include the down time required to move the barge from one boring to the next boring on navigable water. This does not include the initial barge set-up on the first boring or the movement of the barge from the final boring or the movement of the barge from the final boring (these moves shall be part of the Item 2 (a-i). This work will be reimbursed on a per hour basis.

b) Non-Navigable Water (Barge Set-Up)

Rental of support equipment for drilling borings on non-navigable water and the down time required to move the barge from one boring to the next boring are included in this item for barge set-up, and will not be paid for separately.

3) Additional Disassembly and Reassembly

a) Navigable Water

This item shall consist of disassembly, moving and reassembly of barge equipment when the borings are not located on a continuous body of water. Navigable

waters will be defined by the jurisdiction of the United States Coast Guard.

Each such move will be considered as one (1) additional disassembly and the state will pay an additional lump sum for each move required.

b) Non-Navigable Water

This item shall consist of disassembly, moving and reassembly of barge equipment when the water is too shallow within the drilling site to float the barge from one drill location to the next or if borings are not

located on a continuous body of water. Each such move required will be considered as one (1) additional disassembly and reassembly and INDOT will pay an additional lump sum for each such move required.

g. Railroad Expense

Actual cost invoiced by the railroad for railroad permits, flagmen, right of entry, etc., plus ten percent (10%). The ENGINEER shall obtain the written approval of INDOT before any Railroad Expense.

h. Dozer Rental

This work shall entail the procurement of a qualified subcontractor to provide and operate a bulldozer for clearing site and, when applicable, constructing pathways and benches for drill rig set-ups. The charge for this service will be cost plus ten percent (10%). An invoice copy for the dozer subcontractor's services will be required to verify the charges.

i. Skid Rig Moving Time

This item shall pertain to time in excess of one-half (1/2) hour to move the Skid Drill Rig to and from or between the boring locations in difficult terrain. This includes clearing, leveling and benching by drilling crew. This item shall not be used when moving from a project site to the next project site. After the first half-hour, the work shall be paid by the hour measured to the nearest fifteen (15) minutes. This item shall be used only with INDOT's prior approval.

j. Traffic Control

This work shall consist of providing traffic control services in accordance with the INDOT Worksite Traffic Control Manual, when traffic flow must be restricted in order to conduct drilling or coring operations. The charge for this service shall be a daily rate computed to the nearest one quarter day. All warning signs and traffic cones required to meet applicable safety standards shall be provided by the ENGINEER and paid by INDOT at the applicable rate, per nearest 1/4 day.

1) Worksite Set-Up 1 or 6

Worksite set-up 1 or 6 (Two or Four-Lane Roadway): shoulder work (more than 30 minutes).

2) Worksite Set-Up 4

Worksite set-up 4 (Two-Lane Roadway): one lane obstructed (more than 30 minutes).

3) Worksite Set-Up 9

Worksite set-up 9 (Four-Lane Roadway): one lane obstructed (more than 30 minutes).

4) Worksite Set-Up 11

Worksite set-up 11 (Six-Lane Roadway): one lane obstructed (more than 30 minutes).

k. Required Surveying

1) Centerline Surveying

This work shall consist of locating the referenced Survey Line of the proposed alignment, to accurately locate all borings with the use of instrumentation and a qualified survey crew (2 people) when requested by the ENGINEER and approved by INDOT. The charge for this service will be cost plus ten percent (10%).

2) Leveling Survey

This work shall consist of performing leveling circuits from and to established bench marks for the purpose of determining surface elevations at locations of borings and soundings, and for determining elevations needed to draw cross sections. The level circuits should be run to at least third-order accuracy defined by: twelve millimeter (12 mm) times the square root (square meter) of the length of the circuit in kilometers, twelve millimeters divided by kilometers 12mmÖkm. This work shall be performed by the Consultant's Qualified Field Geotechnical Engineer (and one other person) as approved by the Chief Geotechnical Engineer, bench marks used should be to USC&GS datum. The consultant Geotechnical Engineer shall submit the original field notes of the survey to INDOT. The level notes should be kept in accordance with: Exhibit "E", Requirements For Field Surveys, adopted June 26, 1967,

Section D, entitled: Level Note Requirements. Payment shall be cost plus ten percent (10%) for the extra person. The Qualified Field Geotechnical Engineer shall be paid for under E.2.f.p.

l. Field Permittivity Test

The work shall be the preparation of locations and performances of a field test which evaluates the mean coefficient of permittivity of the shoulder base and pavement sub-base material near the critical location of the longitudinal pavement-shoulder joint.

This work shall be performed in accordance with INDOT's current procedures for "Requirements for Field Permittivity Test to Evaluate Pavement Drainage Characteristics".

This work shall be paid for as each test is performed. All costs associated with this test are considered to be a part of this item, including providing a minimum of a two (2) person crew.

m. Special Field Services

This work shall consist of special field services rendered by the ENGINEER other than the normal drilling and sampling work. It shall include special instrument installations, special field tests or observations, which are not otherwise covered. Use of the drilling equipment may be required, and may require the use of both driller and helper. The work shall be paid by the hour measured to the nearest fifteen (15) minutes. This item shall not be used when moving from a drill site to the next drill site, staking borings, etc. This item shall be used only with INDOT's prior approval.

n. Soundings

This work shall consist of continuous flight auger borings with a truck mounted rig, skid mounted rig, barge mounted rig, a powered hand auger, or a hand auger for the purpose of determining the depth to rock or the depth through surficial peat, other unstable soils, man-made waste deposits, etc. Samples are not required.

This item shall also include uncased borings advanced through soil for the express purpose of making core borings in rock or obtaining undisturbed samples at a certain depth. Measurement shall be from the ground surface to the depth augered.

This item shall also include hand borings made in ponds or lakes for the purpose of determining the depth and thickness of unstable sediments in the bottom, etc. Measurement shall be made from the top of water to the maximum depth of drilling work. It shall be the Consultant Geotechnical Engineer's responsibility to determine the elevation and depth of the water at the time the drilling is performed.

o. Casing

This shall consist of furnishing and installing either hollow stem auger or driven casing as previously approved through air, water, soil, shale and or weathered rock to a specified elevation for the purpose of obtaining Shelby tubes, rock cores, installing field instrumentation, etc., if required. Measurement shall be from the water surface (if casing is placed through water) or the ground surface (for land borings), or bridge deck to the depth of casing penetration.

p. Field Geotechnical Engineer

This work shall consist of furnishing a qualified Consultant Geotechnical Engineer for field work for time in excess of eight hours per week. It shall be paid for at the applicable hourly rate for time actually spent at the job site. Overnight expenses and the cost of mobilizing to the job site are included in this item, and are not paid for separately.

3. Soil Sampling

a. Bag Samples

This work shall consist of obtaining a disturbed sample of soil for moisture density relations and CBR testing per AASHTO T-193. The total wet weight of sample shall be not less than one hundred and thirty-six (136) kilograms. The sample shall be placed in appropriate bags and suitable labeled with identifying information. All soil samplers should also be labeled as "SOIL".

Two (2) sealed glass jars of the sampled material shall be taken to be used for a moisture content determination test. The bag sample, to be used for CBR and classification tests, shall be obtained from the near surface (0.3 m to 3.0 m) except in deep cuts where the subgrade could be deeper. The soil sample shall be taken of the most critical predominant fine-grained cohesive soil type encountered on the

project. The sample is generally hand dug or taken from the cuttings of the necessary amount of flight auger holes required to obtain the sample from the appropriate depth.

If the top of the layer of material to be sampled lies within three (3.0) meters of the ground surface, a quantity of one (1) will be paid. An additional quantity of one (1) will be paid for each additional 1.5 meters penetrated to reach the top of the layer of the material to be sampled. No payment is made for the flight auger drilling.

b. Undisturbed Samples

Undisturbed samples, if required, shall be obtained by methods and equipment previously approved. This work shall consist of obtaining undisturbed samples by pressing seventy-six (76) millimeter O.D. or fifty-one (51) millimeter O.D. thin walled tubes into the soil with a continuous push. In soils which are too soft to obtain good recovery by conventional means, a seventy-six (76) millimeter O.D. Stationary piston sampler may be used. An attempt shall be made to push the tube a maximum of six hundred and ten (610) millimeter. Tube length shall be as recommended in Table 1 of AASHTO T-207 or longer to avoid over filling of the tube during sampling. Payment will be made per each undisturbed sample only when recovery is fifty percent (50%) or greater, with a minimum of two hundred and fifty (250) millimeters unless otherwise approved. Smaller, testable samples may be used if previously approved. This work shall be performed in accordance with AASHTO T-207 except where superseded by the following.

Immediately after trimming and cleaning the ends, the samples shall be sealed with approved expanders or by pouring petrowax or comparable materials into each end, placing suitable filler in the remaining void space to prevent movement of the sample, and covering each end with a metal or plastic cap. Bolt holes in the tube shall be covered with tape and both ends of the tube shall be dipped into petrowax or comparable material. Samples shall be kept in a vertical position with the top always up during transportation and storage. Samples shall not be jarred or vibrated and should be properly marked and identified. Tubes should be protected from temperature extremes and under no circumstance should tube samples be allowed to freeze.

c. Additional Split-Spoon Samples

This item shall consist of obtaining additional fifty-one (51) millimeter O.D. or seventy-six (76) millimeter O.D. split-spoon samples as

specified above by the Standard Penetration Test Procedures in accordance with AASHTO T-206. Payment shall be for split-spoon samples obtained other than those required in Item Nos. (E.2.d.2) and (E.2.e.2).

d. Field Vane Shear Test

This work shall consist of performing field vane shear tests in accordance with AASHTO T-223. A quantity of one (1) will be paid for each test performed.

e. Denison Type Core Sample

This work shall consist of taking a core sample in soil, shale or soft rock with a Denison type core sampler. The minimum size shall be seventy-one (71) millimeters in diameter.

4. Shale and Soft Rock Sampling

During the drilling operations whenever a shale or soft rock material is encountered, the Consultant Geotechnical Engineer may be requested by INDOT to send any cores taken of this material to the INDOT Division of Materials and Tests.
When this request is made, the shale samples obtained from all core samples shall be tightly wrapped in cellophane or approved material immediately after removal from the core sampler to prevent moisture loss. The core samples shall be labeled with the following information;

a. Designation Number
b. Project Number
c. Structure Number
d. Road Number
e. Boring Number
f. Station, Offset and Elevation
g. Depth
h. Date
i. Sample Number
j. Sampled By
k. Length of Core Run and Length of Core Recovery
l. Rock Quality Designation, RQD
m. Other

and delivered to the Division of Materials and Tests at the earliest convenient time.

F. FIELD RECORD

All material encountered in each boring shall be carefully examined and visually classified at the time of boring, and a written record (boring log) should be prepared. The boring log shall be on a sheet two hundred and sixteen (216) X two hundred and seventy-nine (279) millimeter in size, and shall show the following information: (a) project designation and project location; (b) boring number; (c) final location of boring by reference to station, offset, and survey line; (d) method of boring, type drill rig and sampling; (e) date of boring and weather; (f) ground elevation measured utilizing a transit or level instrument and referencing to a USC&GS Benchmark or other points of known elevation; (g) numerical thickness and depth of various soil layers to be shown in meter below ground surface or by elevation; (h) a complete description of each soil layer including color, moisture, consistency or density and visual grain size classification; (i) the depth of free water during the drilling, at completion of drilling and at twenty-four (24) hours later and depth the hole stayed open, or "caved in" to; (j) any additional information obtained during the boring shall be shown; (k) blows per one hundred and fifty (150) millimeter increment of drive of split-spoon sampler, sample number, and depth of top and bottom of samples taken; (l) % recovery on split-spoon and undisturbed samples, rock cores, etc.; (m) county; (n) driller; (o) inspector; (p) accessibility of the boring to truck mounted drill rigs (to be used to determine pay item, truck vs. skid boring); (q) backfilling of bore hole.

When rock is encountered and cored, the boring log shall also include the following remarks: (a) numerical thickness and depth of each rock unit; (b) a complete description of each rock unit including color, texture, significant mineralogy, degree of weathering, etc.; (c) Percent Recovery and RQD Values (Rock Quality Designation as described in Appendix Item No. 11.); (d) a description of joints, fractures and bedding planes (i.e., degree of openness, spacing, inclination, etc.); (e) location of core fracturing; (f) type and size of core barrel and depth where casing is used; (g) general descriptions of penetration rate, with significant changes in rate noted; (h) zones of drilling fluid loss; (i) zones of water gain (when air is the drilling fluid); (j) any unusual occurrences such as sudden drop of drill rods, change in color of return wash water, voids in the rock sample, etc.

Fill or embankment material depth limits should be shown on all boring logs as well as the classification of the soil comprising the fill or embankment material. This information should be checked for accuracy by referring to original construction plans to determine the original embankment height. The fill height drilled thru is subtracted from the total depth that the boring stayed open, before applying Special Backfill Guidelines and Items.

The boring logs shall contain all necessary information required to plot the final geotechnical profile, and such information shall also serve as the basis for determining pay quantities.

G. LABORATORY TESTING

1. General

Boring samples shall be submitted for laboratory analysis as the work progresses.

All laboratory tests will be performed in accordance with AASHTO and/or ASTM Standard Methods of Testing as listed herein, except as described below. Tests for which standard or tentative procedures have not been adopted by the above societies shall be governed by Standard Indiana Test Methods, or by other procedures previously approved.

When AASHTO or ASTM Specifications govern, the most current Standard or Interim Specification shall be used for reference.

2. Classification Tests

These tests shall be performed on samples that were obtained for verification of the field classification of the major soil types encountered during the investigation. The number shall be limited to that established by the agreement in effect unless prior approval is given or to those necessary to reasonably establish the stratification without duplication. A minor soil type, if not critical, may be given a visual classification, instead of performing classification tests for reference.

a. Sieve Analysis

This work shall consist of determining the gradation of a sample in accordance with AASHTO T-88. Sieves used shall be U.S. Sieve sizes seventy-five (75) millimeter, fifty (50) millimeter, twenty-five (25) millimeter, 9.5 millimeter and U.S. Sieve 4.75 millimeter, 2 millimeter, 0.425 millimeter, 0.075 millimeter, decanted over the 0.075 millimeter. A grain-size distribution curve shall be provided as a part of this item.

b. Hydrometer Analysis

This work shall consist of the Hydrometer Analysis in accordance with AASHTO t-88, and includes a Specific Gravity Determination performed in accordance with AASHTO T-100. If twenty percent (20%) or more passes the Sieve 0.075 millimeter a Hydrometer Analysis shall be performed. A grain-size distribution curve shall be provided and should include the combined results of the Sieve Analysis.

c. Liquid Limit

This shall consist of the determination of the Liquid Limit in accordance with AASHTO T-89, Method "A" only. Three (3) points shall be determined and no payment will be made for Non-Plastic (N.P.) soil.

d. Plastic Limit and Plasticity Index

This work shall consist of determination of the Plastic Limit and Plasticity Index in accordance with AASHTO T-90. If the soil is found to be non-plastic, then the Liquid Limit shall not be performed, and the AASHTO Group Index shall be reported as zero (0). Payment will be made for plasticity index for non-plastic soils.

e. pH Test

This work shall consist of performing the pH test in accordance with ASTM D-2976 using only distilled water. The test should be performed on all classification test samples, and others as necessary. When the test is performed on moderate to non-organic material, sample size should be twenty (20.0) grams of material passing the sieve 4.75 millimeter. The samples shall be prepared in accordance with AASHTO T-87. When this test is performed as a part of a primary test, it will not be considered as a pay item.

3. Special Tests

These are tests which are performed on bag samples, jar samples, undisturbed samples and/or split-spoon samples to obtain additional information about the soils and their condition. This information is used in analysis of conditions and preparation of recommendations for design and construction.

a. Standard Moisture-Density Relations

This work shall consist of performing the Standard Moisture-Density Relations in accordance with AASHTO T-99 Method D. A minimum of four (4) points on the curve with at least two (2) points on each side of optimum shall be performed. A Standard Moisture-Density Relation Test shall be performed in conjunction with all CBR test samples, and shall be prepared and tested in accordance with AASHTO T-193 except the sample shall be mixed and then cured for forty-eight (48) hours prior to molding the specimens. AASHTO T-99 Method D shall be used in conjunction with all CBR tests.

b. California Bearing Ratio (CBR)

This work shall consist of the determination of the California Bearing Ratio in accordance with AASHTO T-193 with the following exceptions:

1) Six (6) Specimens shall be molded at optimum moisture content, two at approximately ninety (90) percent, two at ninety-five (95) percent and two at one hundred (100) percent, of the maximum dry density, respectively.

2) If the as-molded moisture content of any specimen is more than 0.8 percentage points above or below optimum, the specimen shall be remolded using fresh, uncompacted soil.

3) A minimum surcharge weight of eleven (11) kilogram shall be used for soaking the test specimens. The surcharge should be calculated based on the pavement cross-section. However, 11.3 to 14 kilograms has been found acceptable.

4) A Dry Density (Abscissa) versus C.B.R. (Ordinate) curve shall be plotted and furnished for each sample tested.

c. Moisture Content Test

This work shall consist of determination of moisture content in accordance with AASHTO T-265, on all fine grained samples. When this test is performed as part of a primary test, it will not be considered as a pay item.

d. Unit Weight Determination

This work shall consist of the determination of the Unit Weight by measurement of the length and diameter as performed in accordance with the appropriate part of AASHTO T-234. When this test is performed as a part of a primary test, it will not be considered as a pay item.

e. Specific Gravity

This work shall consist of the determination of the specific gravity in accordance with AASHTO T-100. No payment will be made when performed in conjunction with item No. 2-b, 3-f, and 3-h.

f. Consolidation Test

This work shall consist of performing the consolidation test in accordance with AASHTO T-216 except the load increments shall be 6, 12, 25, 50, 100, 200, 400, 800, and 1600 kPa. This test also includes Specific Gravity, Initial and Final Moisture Content tests, Initial and Final Degrees of Saturation and Unit Weights (density). Time curves for all load increments and e-log-p curve shall also be furnished.

g. Unconfined Compression Test

This work shall consist of performing the Unconfined Compression Test in accordance with AASHTO T-208. This test shall include initial and final Moisture Content test, unit weight determination, visual description of the soil, average strain at failure and average rate of strain to failure. This test shall be performed on seventy-six (76) millimeter undisturbed samples unless other types are specifically approved in advance. This test shall not be performed on non-plastic soils.

h. Triaxial Compression Test

This work shall consist of performing the Triaxial Compression test in accordance with AASHTO T-234. Each test shall consist of three (3) points for plotting a Mohr Failure Envelope and determining the strength parameters. This test shall include initial and final Moisture Content tests, specific gravity, Atterburg Limits, initial and final void ration initial and final degrees of saturation, initial and final Unit Weights (densities), visual Textural description, cohesion, plot of Mohr circles and envelope and sketch of failure. The test shall be one of the following:

(1) Unconsolidated - Undrained (UU) test,
(2) Consolidated - Undrained (CU) test,
(3) Consolidated - Drained (CD) test,

Pore pressure measurements may be required with the UU or CU tests and will be paid for in addition to this test.

i. Loss on Ignition Test

This work shall consist of the determination of the Loss-on-Ignition (Organic Content) in accordance with AASHTO T-267.

j. Remolding of Soil Samples With Lime /Cement/Flyash/ Kiln Dust or any Combination

This work shall consist of preparing three (3) soil samples with lime/cement/flyash/kiln dust/or any combination for additional testing. The quantity of lime/cement, etc., will be between three (3) to ten (10) percent by weight. Remolding of three (3) samples shall be paid as one unit. If additional samples are necessary, INDOT must approve the quantity prior to preparation of samples. Any additional samples will be paid at one third of this rate. This remolded sample could also be prepared for other tests as required.

4. Classification of Soils

All of the soils shall be classified in accordance with AASHTO M-145, and according to the grain-size classification procedure as follows: (Consultants desiring to report Soil Classifications by ASTM 2487-83 may do so in addition to this procedure, however no additional compensation will be allowed).

DEFINITIONS	
Boulders	Over 254 mm
Cobbles	76 mm to 254 mm
Gravel	76 mm to 200 mm
Coarse Sand	Sieve 2 mm to .425 mm
Fine Sand	Sieve .425 mm to .075 mm
Silt	.002 to .075 mm
Clay	Smaller than .002 mm
Colloids	Smaller than .001 mm

a. Soils Having 0 to 19% Retained on 2 millimeter

CLASSIFICATION	% SAND & GRAVEL	% SILT	% CLAY
Sand	80 - 100	0 - 20	0 - 20
Sandy Loam	50 - 80	0 - 50	0 - 20
Loam	30 - 50	30 - 50	0 - 20
Silty Loam	0 - 50	50 - 80	0 - 20
Silt	0 - 20	80 - 100	0 - 20
Sandy Clay Loam	50 - 80	0 - 30	20 - 30
Clay Loam	20 - 50	20 - 50	20 - 30
Silty Clay Loam	0 - 30	50 - 80	20 - 30
Sandy Clay	50 - 70	0 - 20	30 - 50
Silty Clay	0 - 20	50 - 70	30 - 50
Clay	0 - 50	0 - 50	30 - 100

b. Soils Having 20% or More Retained on 2 millimeter and More Than 20% Passing 0.075 millimeter Silt and Clay

Classify in accordance with Section G.4.a, followed by term describing relative amount of gravel according to following:

20% to 35% gravel - "with some gravel"
36% to 50% gravel - "and gravel"

Examples: Clay Loam with some gravel
Sandy Loam and gravel

c. Soils Having 20% or More Retained on 2 millimeter and Less than 20% Passing 0.075% millimeter

CLASSIFICATION	% GRAVEL	% SAND	% SILT	% CLAY
Gravel	85 - 100	0 - 15	0 - 10	0 - 15
Sandy Gravel	40 - 85	15 - 40	0 - 20	0 - 20
Gravelly Sand	20 - 40	40 - 80	0 - 20	0 - 20
Sand & Gravel	20 - 50	20 - 50	0 - 20	0 - 20

NOTE: If the gradation of a given sample does not meet the requirements for any classification exactly, it shall be placed in the classification to which it comes the closest.

d. Classification System for Organic Soils

The following classification system should be used for Organic Soils.

With Trace Organic Matter	1% to 6%	Organic Matter
With Little Organic Matter	7% to 12%	Organic Matter
With Some Organic Matter	13% to 18%	Organic Matter
Organic Soil (A-8)	19% to 30%	
Peat (A-8)	More than 30%	

e. Classification System for Marly Soils

The following classification system based on Calcium Carbonate equivalent should be used for Marly Soils.

With Trace Marl	1 % to 9 %
With Little Marl	10 % to 17 %
With Some Marl	18 % to 25 %
Marly Soil (A-8)	26 % to 40 %
Marl (A-8)	More than 40 %

f. Moisture Modifiers for Soil Classification

When describing the moisture condition in the soil sample, the following moisture modifiers should be used:

Dry
Slightly Moist
Moist
Very Moist
Wet

RQD (ROCK QUALITY DESIGNATION)	DESCRIPTION OF ROCK QUALITY
0 - 25	VERY POOR
25 - 50	POOR
50 - 75	FAIR
75 - 90	GOOD
90 - 100	EXCELLENT

RELATIVE DENSITY	
TERM	"N" VALUE
VERY LOOSE	0 - 5
LOOSE	6 - 10
MEDIUM DENSE	11 - 30
DENSE	31 - 50
VERY DENSE	OVER 50

Rule of Use: Non-plastic

CONSISTENCY	
TERM	**"N" VALUE**
VERY SOFT	0 - 3
SOFT	4 - 5
MEDIUM STIFF	6 - 10
STIFF	11 - 15
VERY STIFF	16 - 30
HARD	OVER 30

Rule of Use: PI is 5 or Greater
Where the PI is greater than zero, but less than 5 consistency or density may be used.

H. GEOTECHNICAL REPORT

1. General

The Geotechnical Report shall be the presentation of all data obtained during the Investigation, both in the field and laboratory, all engineering analyses and recommendations for the use or satisfactory treatment of various soils and soil conditions encountered on the project. A maximum of ten (10) copies of the Geotechnical Report will be required, with the actual number being requested by INDOT.

If a pavement soil subgrade investigation is required, it shall be performed as per the requirements of INDOT - Geotechnical Section as outlined in "Procedures for Performance of Soil Subgrade Investigation Under Existing Pavement", and the results shall be included in the Geotechnical Report.

2. Contents of Report

a. General Information

1) A discussion of the location of the project (including the beginning and ending stations), project identification and background, scope of proposed construction, including proposed pavement section.

2) The date, month and year when the field investigation was made.

3) A general description of climatic conditions during field investigation.

4) A general description of the geology and soils encountered on the project, and a description of the terrain, to include drainage, erosion patterns, highwater elevation, flooding, and any other specific conditions which may be of value in the design of bridges, culverts and other structures.

5) Any other information which may be of value for the proper interpretation of the field survey data.

b. General Recommendations

The Geotechnical Report shall include general recommendations concerning design and construction procedures for earthwork, roadway, subgrade, bridge, retaining walls, culvert and other structures etc., as applicable.

c. Detailed Geotechnical Conditions and Recommendations

The project shall be described by areas of similar soils and terrain features or conditions from the beginning of the project to the end. The soils of each area shall be generally described; specific problems or conditions shall be explained; and recommendations with the results of engineering analyses (where applicable) shall be made relative to any special embankment construction; cut slope recommendations in soil or rock; soil subgrade recommendations, subgrade removal, replacement, or treatment, some possible causes for the existing subgrade problems; removal of unsuitable soil; rock swell factors; drainage installations; the use of channel change materials, and/or any other factors affecting design or construction of the project. Any investigation of interchanges, S-lines and/or channel relocations shall also be a part of the report.

Whenever it is recommended to install field monitoring equipment and/or devices such as piezometers, settlement plates, should stakes, toe stakes, etc., the recommendations should include the purpose and/or objective, proposed locations, an approximate schedule as to the frequency of readings, controls which can be used during construction to assure proper performance based on the design assumptions, etc.

d. Boring Logs

Logs of all borings (including structure) shall be included in the Appendix of the Report. The logs shall be based on the field logs and laboratory test data. The logs shall contain all the information recorded on field logs as specified in Section F., FIELD RECORD, except the description of soil layers shall include grain-size classification and AASHTO classification based on laboratory test data, and each soil layer shall be referenced to a laboratory sample number. A structure boring location plan view shall be included in the appendix of the Geotechnical Report.

e. Test Data

The results of all laboratory tests on various samples shall be tabulated and included in the Appendix of the Report. The tabulation shall identify each sample as to sample number, boring number, location and depth, and shall include all results obtained under items G.2. and G.3., as set out under Section G., LABORATORY TESTING. Separate tabulations shall be included for classification test results, strength test results, and other special test results.

f. Engineering Analysis

The work described herein shall include review and correlation of various test results as to embankment stability, material placement and other geotechnical engineering considerations. Sketches, Assumptions, calculations, etc., (where applicable) of all final engineering analyses shall be included in the Appendix of the Report. The source of the analysis, the input and output data (properly labeled) all shall be provided if computerized analysis methods are utilized. The Consultant Geotechnical Engineer shall also attend all field checks, conferences, etc., as requested by INDOT. Methods of analysis shall have prior approval.

1) Settlement Analysis

This work shall consist of performing settlement analysis at a specific embankment cross-section based on consolidation test results in fine grained soils or, based on blow count and the soil gradation in granular soils. The Consultant Geotechnical Engineer shall furnish computations for total estimated settlement (cross-section of up to three (3) points if requested), a plot of percent total estimated settlements vs. time (at the point of maximum settlement unless otherwise approved) assuming the most likely drainage conditions, etc.

The analysis can be for the proposed embankment, a proposed and existing embankment, etc. A quantity of one (1) will be paid for each section analyzed and a quantity of one-third (1/3) will be paid for each additional point approved exceeding three.

2) Sand/Wick Drain Analysis

This work shall consist of performing Sand/Wick Drain Analysis and Design, and determining the drain/wick diameter and spacing at a specific embankment section based on consolidation test results. The Consultant Geotechnical Engineer shall furnish an estimated coefficient of horizontal consolidation, a plot of percent total estimated settlement vs. time using the optimum sand/wick drain design, the limits from station to station and offset to offset where the proposed sand/wick drains should be installed and any other information needed for a complete sand/wick drain design. A quantity of one (1) will be paid for the complete Sand/Wick Drain Analysis made at each location.

3) Sliding Block Slope Stability Analysis

This work shall consist of making Sliding Block Slope Stability Analyses at specific sections to analyze proposed or existing conditions. One (1) analysis will be authorized for payment for each section analyzed. However, prior approval must be obtained before analyzing more than one model at a specific section. For nonsymmetrical cross-sections where more than one (1) part of the cross-section is analyzed, a quantity of one (1) will be authorized for payment for each separate analysis performed. Additional analysis will be authorized for each corrective measure to be analyzed. A Stage Construction alternate will be considered as one (1) additional analysis regardless of the number of stages analyzed. All corrective measures shall be defined as to the limits of the correction.

Factor of Safety Computations shall be made for various assumed failure surfaces until an apparent minimum factor of safety has been established for each analysis. All models will be approved by INDOT prior to performing the analysis. A computer program (preferring PC STABL5 or latest version) should be used for analyzing. The printout of input data, output data and plot of failure surfaces should be included with the analysis.

4) Rotational Slope Stability Analysis

This work shall consist of making Rotational Slope Stability Analysis at specific sections to analyze proposed or existing conditions. One (1) analysis will be authorized for payment for each section analyzed. However, prior approval must be obtained before performing the analysis. For nonsymmetrical cross-sections where more than one part of the cross-section is analyzed, a quantity of one (1) will be authorized for payment for each separate analysis performed. Additional analyses will be authorized for each corrective measure to be analyzed. A Stage Construction alternate will be considered as one (1) additional analysis regardless of the number of stages analyzed. All corrective measured shall be defined as to the limits of the correction.

Factor of Safety Computations shall be made for various assumed failure surfaces until an apparent minimum factor of safety has been established for each analysis. All models will be approved by INDOT prior to performing the analysis. A computer program (preferably PC STABL5 or latest version) should be used for analyzing. The printout of input data, output data and plot of failure surfaces should be included with the analysis.

5) Bridge Foundations Analysis

This work shall consist of Bridge Foundation Analyses including recommendations.

a) Shallow Foundation

This item shall include all analyses and computations required to make complete recommendations for a satisfactory shallow foundation to support the proposed loading conditions including axial and loads at each pier location, except for settlement analysis. Shallow foundations are defined as spread footings, reinforced concrete mats, etc. Each pier analyzed shall be considered as one (1) analysis.

b) Deep Foundation

This item shall include all analyses and computations required to make complete recommendations for a satisfactory deep foundation to support the proposed loading conditions at each pier location, except for settlement analysis. Deep Foundations are defined as piles, drilled shafts, etc. If H-piles are the most feasible alternative, then 356, 490, and 623 KN should be analyzed at each pier location for 203 millimeter, 254 millimeter and 305 millimeter sections respectively or the capacity as required by the structural design engineer. Each pier analyzed shall be considered as one (1) analysis, (using the Spile computer program).

c) Settlement Analysis for Bridge Pier Foundations

This work shall consist of performing Settlement Analysis (cross section if requested by INDOT) at a specified bridge pier foundation based on consolidation test results. The ENGINEER shall furnish computations for total estimated settlement, a plot of percent total estimated Settlement vs. Time assuming the most likely drainage conditions, etc. A quantity on one (1) will be paid for each bridge pier foundation analyzed, for each of the following conditions:

(1) Bridge Pier
(2) Embankment-plus-pier
(3) Embankment-plus pier-plus all other loads

d) Foundation on Bedrock

This work shall consist of making bridge recommendations when the foundation should be placed on bedrock whether the foundations are deep or shallow. This pay item will be used only when no analysis is required for any support of the bridge structure. A quantity of one (1) will be paid for each structure.

e) Generalized Subsurface Profile

A separate generalized subsurface profile shall be prepared for each Bridge Foundation Analysis and included as part of the calculations. This drawing shall show the existing ground line, the proposed grade line, the location of the structure and its supports the estimated soil and rock stratification within the limits of the proposed structure, the location of each structure boring, hydrologic data, standard penetration values adjacent to the boring location, ground water levels, etc., as applicable.

6) Retaining Structure Analysis

This work shall consist of Retaining Structure Analyses including recommendations which shall include conventional retaining walls, bridge abutments, bin walls, drilled-in-piers, and MSE walls. Separate pay items as defined below will be made for either (a) Shallow Foundation or (b) Deep Foundation or any other retaining type structures. The analyses and recommendations shall include all computations necessary to assure the stability of the retaining structure, except for settlement analysis. Each section of retaining structure analyzed shall be considered as one (1) analysis. All models will be approved by INDOT prior to performance of the analysis.

a) Conventional Retaining Structure

Conventional retaining structures including retaining walls, bridge abutments, and other retaining-type structures, except for pile or drilled-in-pier types.

(1) Shallow Foundation

This item shall include all analyses and computations required to make complete recommendations for a satisfactory shallow foundation to support the

proposed loading conditions at each section, except for settlement analysis. Shallow foundations are defined as spread footings, reinforced concrete mats, etc.

(2) Deep Foundation

This item shall include all analyses and computations required to make complete recommendations for a satisfactory deep foundation to support the proposed loading conditions at each section, except for settlement analysis. Deep foundations are defined as piles, drilled shafts, etc.

(3) Settlement Analysis for Retaining Wall Foundations

This work shall consist of performing Settlement Analysis (cross section if requested) at specified section based on consolidation test results. The ENGINEER shall furnish computations for total estimated settlement, a plot of percent total estimated Settlement vs. Time assuming the most likely drainage conditions, etc. A quantity of one (1) will be paid for each section analyzed.

b) Pile Retaining Structure Analysis and Recommendations

(1) Free Standing Structure

This item shall include the analysis and computations required to determined the lateral loads which will be imposed on the structure elements, and the depth of embedment required for stability of a typical section, etc. The final recommendations shall include the station limits of the structural elements, their offsets, penetration depths, the soil and/or rock stresses for which the elements of the retaining structure should be designed, etc. Any other design parameters which are pertinent to the recommendations for such a retaining structure should be designed, etc. Any other design parameters which are pertinent to the recommendations for such a retaining structure should also be included as part of this item.

(2) Retaining Structure with Tie-Back System

This work shall be the same as described above under Item b-1. Except for the additional recommendations pertaining to a tie-back system. The recommendations for the tie-backs shall include the capacity of the tie-backs, the penetration required for stability, the spacing of the tie-backs, any other design parameters pertinent to the tie-back system recommendations, etc.

c) Drilled-in-Pier Retaining Structure Analysis and Recommendations

(1) Free Standing Structure

This item shall include the analysis and computations required to determine the lateral loads which will be imposed on the structural elements, the depth of embedment required for stability of a typical section, etc. The final recommendations shall include the station limit of the structural elements, their offsets, penetration depths, the soil and/or rock stresses for which the elements of the retaining structure should be designed, etc. Any other design parameters which are pertinent to the recommendations for such a retaining structure should also be included as part of this item.

(2) Retaining Structure with Tie-Back System

This work shall be the same as described above under item (b-1). Except for the additional recommendations pertaining to a tie-back system. The recommendations for the tie-backs shall include the capacity of the tie-backs, the penetration required for stability, the spacing of the tie-backs, and other design parameters pertinent to the tie-back system recommendations.

A separate generalized subsurface profile shall be prepared for each retaining structure analysis as described above for Bridge Foundation Analysis.

g. Dynamic Pile Analysis

This work shall consist of performing a wave equation analysis using a computer program (WEAP 87 or others as approved by INDOT) and writing

recommendations. This shall include all analyses and computations required to make complete recommendations for an adequate pile driving system at each bridge structure for the proposed loading conditions.

All necessary curves shall be prepared for each pile driving system with a specific pile to show the conditions during driving operations. "Blows per meter" vs "Ultimate resistance" and "Blows per meter" vs "Driving Stress" shall be plotted. Based on the maximum allowable compressive stress, blow count per meter at ultimate resistance and minimum driving time required to achieve ultimate resistance, an adequate pile driving system shall be recommended. Also, any other information or recommendations required by INDOT shall be provided.

INDOT will provide for the ENGINEER the information on the proposed pile driving system adequate to fill out the upper portion of Form 2 (Driving System, Pile and Soil Date). The ENGINEER will determine soil parameters during his Geotechnical Investigation.

Each pile driving system analyzed at a bridge shall be considered as one (1) analysis, with the prior approval of INDOT. When this work is done on a part of item 73, it will not be paid for separately.

h. Deep Dynamic Compaction Analysis

This work shall consist of Deep Dynamic Compaction Analysis including recommendations, etc. This shall include all necessary analyses and computations required to make complete recommendations for a satisfactory foundation to support the proposed loading of the embankment and/or to minimize the future settlement to a tolerable limit. Prior approval of INDOT must be obtained before performing the analysis. The ENGINEER shall furnish computations for densification of foundation soils or material and all necessary curves and sketches, etc. The ENGINEER shall prepare the curves to show the relationship between the weight, height, and number of drops, etc. and the densification of the soil or material to facilitate the operation during construction, etc.

Each site analyzed shall be considered as one (1) analysis for payment purposes.

i. Seepage Analysis

This work shall consist of performing seepage analysis including recommendations at specific sections to estimate the quantity of seepage through and/or underneath the embankment, etc. Stability against piping and

any other related analysis shall be analyzed as a part of the seepage analysis. However, prior approval of INDOT must be obtained before performing the analysis.

The ENGINEER shall furnish computations for estimated seepage, calculated factor of safety against piping and all necessary curves and sketches. Additional analysis will be authorized for corrective measures at specific sections.

j. Geotechnical Profile

The following requirements have been established for the Geotechnical Profile Drawings to be submitted with the completed Geotechnical Investigation Report.

1) Sheet 1-Title Sheet

This may be a reproducible of the Title Sheet used by the Design Consultant for the design plans, modified as necessary.

2) Sheet 2 - Legend Sheet

3) Sheet 3-Tabulation of Classification Test Data

Classification test data shall be tabulated on a separate sheet of the Geotechnical Profile. Such tabulation shall include laboratory sample number, field sample number, boring number, station, offset, depth of sample, color, textural or grain size classification, AASHTO classification and the test results obtained from mechanical analysis, liquid limit, plastic limit, and plasticity index. This table should also include maximum dry density, optimum moisture and recommended CBR at 93 percent and ninety-seven (97) percent of maximum dry density, corresponding to one-hundred and fifty (150) millimeter and six hundred and ten (610) millimeter of Special Subgrade Treatment respectively, if determined.

4) Other Plan and Profile Sheet Requirements

a) Scale

The Geotechnical Profile plan and profile sheets with the borings and data shall be plotted to a vertical scale of not more than twenty-five (25) millimeter = three (3) meter, and to a horizontal scale of not more than twenty-five (25) millimeter =

thirty (30) meter. Each sheet shall be identified as to project and route number, structure number, county, line designation, Fiscal Year, Federal Road Design Region, and the scale to which it is drawn.

b) Groundwater

Elevation of subsurface water during the boring, at completion of boring, and twenty-four (24) hours later, shall be indicated by suitable symbols. The use of color as a symbol will not be permitted.

c) Additional Sheets

Additional sheets as required to plot soil or rock cross-sections, peat or unstable soil profiles, rock profiles, interchange plan and profile views, etc.

d) Permanent Originals

The Geotechnical Profile shall be prepared in ink on linen, mylar, or other material with prior approval, to provide permanent originals with will not deteriorate or fade with age.

e) Centerline, Groundline and Proposed Grade Line

The Geotechnical Profile will show the centerline profile, groundline, and the proposed grade line for each pavement. The proposed grade line shall be indicated by a line heavier than used to indicate the ground line. Each profile sheet shall also have a plan view with the location of all borings plotted. The borings should be plotted on the particular plan and profile sheet where they will provide the most information pertinent to the proposed construction.

f) Test Samples

The location and depth from which test samples were obtained shall be indicated and referenced to the "Classification Test Data Sheet", by sample number.

g) Roadway Borings

All roadway borings shall be plotted on the Geotechnical Profile, Each soil strata shall be given its proper color, moisture modifier, consistency or density, blow counts, stratigraphic symbols, station, offset, line, boring number, and any pertinent remarks, grain size classification and AASHTO Classification. Any test data, such as natural moisture content, natural density, unconfined compressive strength, void ratio, etc., shall also be shown on the borings at their proposed depth.

h) Structure Borings

Bridge, retaining wall, and other structure borings are usually not shown on the plans and profile drawings. If on a Geotechnical Profile there is a void in the subsurface information, these borings should be plotted on the plan and profile drawings to fill this void, usually one (1) typical boring showing the most critical and deepest subsurface information per structure.

If two (2) or more borings are made at or near one station or along a given line to develop a rock or soil cross-section only the boring showing the most useful information should be plotted on the Geotechnical Profile drawings so that they show the maximum and pertinent subsurface information while being presented in a neat, clear, meaningful manner.

When two (2) or more borings are placed at the same station or in line for the same station or in line for the development of a cross-section, either soil or rock, these borings will be plotted on their respective cross-section showing both the existing ground line and the proposed grade line.

i) Soundings

If soundings are made, these soundings should be plotted on a separate sheet as a profile or a cross-section depending on their purpose (i.e., rock soundings, peat soundings, rock cross-sections, etc.). These cross-sections and/or profiles shall be drawn regardless of who performed the soundings (i.e., either INDOT or the Geotechnical Consultant).

If only a few isolated soundings are made along the roadway, these may be plotted in profile view on the Geotechnical Profile drawings, if space is available and if it is legible. All soundings should be plotted and labeled correctly in plan view.

j) Limits of Unsuitable Material

Limits of peat or unsuitable material to be removed, the proposed grade line, rock line, etc., shall be shown on sounding profiles and cross-section.

I. SUPERVISION

1. General

All phases of the Roadway and Bridge Geotechnical Investigation, including boring and sampling, laboratory testing, analyses and preparation of the Geotechnical Report, shall be under the direct supervision of the qualified Consultant Geotechnical Engineer. The Qualified Consultant Geotechnical Engineer shall be approved by INDOT.

2. Scheduling

After the preliminary field check, as previously mentioned, the scope of work for the project should be defined on a tentative basis. The qualified Consultant Geotechnical Engineer shall send in writing a proposed schedule for the completion of the field work and the date when the complete Geotechnical Report and Profile will be transmitted to the INDOT - Chief Geotechnical Engineer after the preliminary boring location plan is approved. If it appears that the aforementioned schedule must be altered during the progress of the work, the Consultant Geotechnical Engineer shall send in writing to the INDOT- Chief Geotechnical Engineer the revised schedule and a statement explaining the reasons for the schedule change.

3. Field Supervision

During the boring and sampling phase, the qualified Consultant Geotechnical Engineer shall so organize the work that the Consultant Geotechnical Engineer can spend at least eight (8) hours per week (minimum) with the drilling crews. If more than one (1) drill crew is used they shall be so operated that the Consultant Field Geotechnical Engineer can supervise them with a minimum of travel from one (1) crew to another. Structure subsurface investigations shall require the same amount of field supervision as roadway subsurface investigation. Prior authorization shall be obtained regarding field supervision in excess of eight (8) hours per week.

4. Maintaining Cost Records

The Consultant Geotechnical Engineer shall maintain records to reflect the running total of work accomplished for all items of work, including testing, as the work progresses. These records shall be up-to-date and available for inspection at all times. As the work progresses, it may be advantageous for the qualified Consultant Geotechnical Engineer to consult with the INDOT - Geotechnical Section prior to executing certain laboratory tests and/or engineering analyses. The Consultant Geotechnical Engineer may elect to proceed with the work using reasonable engineering judgement without consulting with INDOT - Geotechnical Section as long as the actual quantities used do not exceed the estimated agreement quantities. If at any time it appears that a major overrun will be necessary, the Consultant Geotechnical Engineer shall obtain approval prior to performing work which will be in excess of the estimated amounts.

J. MEASUREMENT AND PAYMENT

1. Boring and Sampling

a. General

The unit prices in the Agreement for the respective items shall cover supervision by a Consultant Field Geotechnical Engineer as described previously; settlement of all damage claims; contacting property owners; marking the boring locations and establishing boring elevations in the field, supplying clean sample jars, cases, bags, core boxes, and sampling tubes; making all of the borings, obtaining all samples; packing or crating and delivery of all samples; preparation of field records, measuring water level; machinery, signs, materials, supplies, equipment, permits, and utilities clearances necessary and incidental to completing the work in accordance with the Agreement and those Requirements for Geotechnical Investigation. Railroad Expenses will be paid for as a separate item.

b. Measurement

The quantities for the items of Boring and Sampling shall be as described in Section E.

c. Basis of Payment

The basis of payment shall be the quantity of accepted work times the unit price in the Agreement for each of the items of Boring and Sampling.

d. Pay Items

The pay Items for Boring and Sampling are as follows:

1) Hand Borings ..... (m)
2) Truck Mounted Borings With .6 meter Auger Head ..... (m)
3) Truck Mounted Borings With Split-Spoon Sampling
   Road ..... (m)
   Bridge ..... (m)
4) Truck Mounted Core Borings
   Road ..... (m)
   Bridge ..... (m)
5) Truck Mounted Borings Through Bedrock or Boulders ..... (m)
6) Skid Mounted Borings With .6 meter Auger Head ..... (m)
7) Skid Mounted Borings With Split-Spoon Sampling .....
   Road ..... (m)
   Bridge ..... (m)
8) Skid Mounted Rock Core Borings .....
   Road ..... (m)
   Bridge ..... (m)
9) Skid Mounted Borings Through Bedrock or Boulders ..... (m)
10) Railroad Expense ..... Cost + 10%
11) Dozer Rental ..... Cost + 10%
12) Skid Moving Time ..... (Hour)
13) Traffic Control .....
   a) Worksite Setup 1 or 6 ..... (per day)
   b) Worksite Setup 4 ..... (per day)
   c) Worksite Setup 9 ..... (per day)
   d) Worksite Setup 11 ..... (per day)
14) Surveying .....
   a) Centerline SurveyCost ..... Cost + 10%
   b) Leveling Survey ..... Cost + 10%
15) Field Permittivity Test .....
   a) 1-5 Tests Per Authorization ..... (ea)
   b) More Than 5 Tests Per Authorization ..... (ea)
16) Field Vane Shear Test ..... (ea)
17) Denison Type Core Sample ..... (ea)
18) Soundings ..... (m)
19) Casing ..... (m)
20) Bag Samples .....
   a) 136 kilogram ..... (ea)
   b) 110 kilogram ..... (ea)

21) 51 millimeter Undisturbed Samples.....(ea)
22) 76 millimeter Undisturbed Samples.....(ea)
23) 76 millimeter Undisturbed Samples W/Stationary-Piston.....
Sampler.....(ea)
24) Additional Split-Spoon Samples.....
a) 51 millimeter Split-Spoon Sample.....(ea)
b) 76 millimeter Split-Spoon Sample.....(ea)
25) Floating Equipment For Machine Boring.....
a) Navigable Water.....
(1) Barge Set-Up.....(ea)
(2) Rental of Support Equipment.....Cost + 10%
(3) Drill Rig Down Time.....(per Hour)
b) Non-Navigable Water Barge Set-up.....(ea)
c) Additional Disassembly and Reassembly.....
(1) Navigable Water.....(ea)
(2) Non-Navigable Water.....(ea)
26) Floating Equipment For Hand Borings.....(Ls)(m)
27) Twenty Four Hour Water Levels.....
a) Field Measurement-..... (L.S. per borehole)
b) PVC Slotted Pipe..... (m)
28) Special Backfilling of Boreholes.....
a) 3 to 9 meters Deep.....(L.S. per borehole)
b) More than 9 meters Deep..... (m)
29) Special Field Services.....(per hour)
30) Mobilization.....
a) Mobilization of Equipment..... (L.S.)
b) Mobilization of Mileage..... (per kilometer)
31) Remobilization.....
a) Mobilization of Equipment..... (L.S.)
b) Mobilization of Mileage..... (per kilometer)
32) Field Geotechnical Engineer.....(per hour)

2. Laboratory Testing

a. General

The unit prices in the Agreement for the respective items shall cover supervision by a Consultant Geotechnical Engineer; performance of tests which includes all testing, determinations, measurements, computations, tabulations and other work required in the performance or the primary test; and all services, labor, storage, equipment, transportation, materials, and supplies necessary for and incidental to the completion of the work specified herein, including work reasonably implied.

b. Measurement

The quantities for the items of Laboratory Testing shall be the actual number of tests completed and accepted. Items performed as a part of the primary test shall not be considered as an item of payment.

c. Basis of Payment

The basis of payment shall be the quantity of accepted work times the unit price in the Agreement for each of the items of Laboratory Testing.

d. Pay Items

The Pay Items For Laboratory Testing Are As Follows:

1) Sieve Analysis.....(Ea.)
2) Hydrometer Analysis.....(Ea.)
3) Liquid Limit.....(Ea.)
4) Plastic Limit & Plasticity Index.....(Ea.)
5) pH Test.....(Ea.)
6) Standard Moisture-Density Relations.....(Ea.)
7) California Bearing Ration (CBR).....(Ea.)
8) Moisture Content Test.....(Ea.)
9) Unit Weight Determination.....(Ea.)
10) Specific Gravity Test.....(Ea.)
11) Consolidated Test.....(Ea.)
12) Unconfined Compression Test.....(Ea.)
13) Triaxial Test, Unconsolidated, Undrained.....(Ea.)
14) Triaxial Test, Consolidated, Undrained.....(Ea.)
15) Triaxial Test, Consolidated, Drained.....(Ea.)
16) Pore Pressure Measurements for Triaxial Test.....(Ea.)
17) Loss on Ignition Test.....(Ea.)
18) Remolding of Soil Samples.....(Ea.)

3. Engineering

a. General

The unit prices in the Agreement for the respective items shall cover supervision by a qualified Geotechnical Engineer; all analysis and recommendations; preparation, duplication and delivery of the Geotechnical Report along with the original Geotechnical Profile Drawings; attendance of

meetings and conferences with the officials of INDOT and other interested agencies as may be required in connection with the work; and all services, labor, equipment, transportation, materials, and supplies necessary and incidental to completing the work specified herein, including work reasonably implied.

All original field boring and sounding logs and original laboratory test data should be retained by the Consultant Geotechnical Engineer for a minimum period of five (5) years after completion of the project, unless otherwise approved.

b. Measurement

The quantities for the items of Engineering shall be the number of analysis actually performed and accepted. Engineering items shall include review and correlation of various test results. The item of Geotechnical Report shall be on the basis of a lump sum for the entire project and includes the Geotechnical Profile.

c. Basis of Payment

The basis of payment shall be the quantity of accepted work times the unit price in the Agreement for each of the items of Engineering.

d. Pay Items

The Pay Items For Engineering Are As Follows:

1) Settlement Analysis and Recommendation (Ea.)
2) Sand/Wick Drain Analysis and Recommendation (Ea.)
3) Sliding Block Slope Stability Analysis & Recommendation
   a) C/O = O, C & O Analysis (Ea.)
   b) Corrective Measures (Ea.)
   c) Stage Construction Corrective Measure (Ea.)
4) Rotational Slope Stability Analysis & Recommendation
   a) C/O = O, C & O Analysis (Ea.)
   b) Corrective Measures (Ea.)
   c) Stage Construction Corrective Measure (Ea.)
5) Bridge Foundation Analysis & Recommendation
   a) Shallow Foundation (Ea.)
   b) Deep Foundation (Ea.)
   c) Settlement Analysis for Bridge Pier Foundations
      (1) Bridge Pier (Ea.)
      (2) Embankment Plus Pier (Ea.)

		(3) Embankment Plus Pier Plus All Other Loads	(Ea.)
6)	Retaining Structure Analysis & Recommendations		
	a)	Conventional Retaining Structure	
		(1) Shallow Foundation	(Ea.)
		(2) Deep Foundation	(Ea.)
		(3) Settlement Analysis For Retaining Wall Foundations	(Ea.)
	b)	Pile Retaining Structure Analysis & Recommendation	
		(1) Free Standing Structure	(Ea.)
		(2) Retaining Structure With Tie-Back System	(Ea.)
	c)	Drilled-In-Pier Retaining Structure Analysis & Recommendation	(Ea.)
		(1) Free Standing Structure	(Ea.)
		(2) Retaining Structure With Tie-Back System	(Ea.)
7)	Dynamic Pile Analysis and Recommendation		(Ea.)
8)	Deep Dynamic Compaction Analysis & Recommendation		(Ea.)
9)	Seepage Analysis and Recommendation		(Ea.)
10)	Geotechnical Roadway Profile and Related Work		
	a)	With Soil Subgrade Drawings	(Per km)
	b)	Without Soil Subgrade Drawings(	Per km)
	c)	Soil Subgrade Drawings (only)	(Per km)
11)	Geotechnical Roadway Report		
	a)	With Soil Subgrade Investigation(	Per km)
	b)	Without Soil Subgrade Investigation(	Per km)
	c)	Soil Subgrade Investigation (only)	(Per km)

18 December, 1990

Memorandum

To: Mr. D. Andrewski, Chairman
Pavement Design Committee

From: W. J. Sisilano, Member
Pavement Design Committee and
Chief Geotechnical Engineer

Subject: New Procedure for CBR Determination

The Indiana Department of Transportation has in the past and continues to use California Bearing Ratio (CBR) values for pavement design. Subgrade Resilient Modulus will likely be used upon completion of the JHRP project currently active at Purdue University under the guidance of Professors Altschaeffl and White.

Past Procedures

In the past, preliminary CBR values were provided to the Designers so they could obtain a Preliminary Pavement Design. Generally these values were taken from the historical Geotechnical Data Bank and were usually conservative since they were only being used for preliminary pavement design and actual CBR values would generally be determined for each specific project. However, oftentimes the Designers would not obtain a final pavement design based upon the final CBR values.

Previously during the Geotechnical Investigation for a project, a CBR test was performed only on a sample of the most critical soil type. Consideration was not given to the most predominant soil, etc. Therefore, the results were intentionally conservative for the following reasons.:

1. There was no consistency in the decisions made in the pavement design process since there was no pavement design committee. The pavement and drainage decisions were the responsibility of the designer for each project.

2. The source of the borrow material on the project was not known. This was left up to the contractor.

3. There was considerable skepticism whether we were getting the full depth of special subgrade treatment when it was specified. It is very important that we

follow the proper moisture and density controls for the full depth of special subgrade treatment specified.

Current and Proposed Procedures

As a result of the Pavement Design Committee meeting of 28 August 1990, preliminary pavement design CBR values will no longer be required. The FHWA representatives in attendance at this meeting agreed with this action.

The Geotechnical Section will hereafter initiate the following measures as a means of obtaining less conservative final CBR values:

1. Typically, a minimum of two CBR tests will be performed on each major project (except for small structure pipes, intersection improvements and bridge approaches up to 800'). One sample shall be selected from the predominant soil and one from the most critical soil.

   The critical soil will be determined from the predominant soil source. If the critical soil does not exist in sufficient quantity, engineering judgement shall be used in selecting another critical soil.

2. Additional CBR tests shall be performed on longer projects where significant differences in pavement thickness are expected due to large variations in the anticipated CBR values.

3. CBR values shall be provided for 24 inches of special subgrade treatment. If the project is within a municipality where utilities might be a problem, a CBR value shall also be provided for 6 inches of special subgrade treatment.

General Comments

1. In cuts, soils having a CBR value of less than two (2) warrants subgrade modification such as undercutting and replacing with select material, lime modification, etc. To improve the subgrade.

2. In fills, soils having a CBR value less than two (2) should not be used in the upper two feet of the subgrade; i.e.: not within the special subgrade treatment zone.

3. The CBR test shall not be performed on shale and rock. These materials should not be used in the upper two (2) foot of the subgrade.

4. The CBR value shall be based on actual test values when the historical geotechnical data bank is used. (Small projects only).

5. Moisture content tests shall be performed on all fine grained soils in order to have a better understanding of the condition of the subgrade soil (on every six inches).

6. In general, a CBR test shall not be performed on granular material (20% or less passing the no. 200 sieve).

WJS/NZ/ta

cc: All Pavement Design Committee Members
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File